

Chemistry of Invisible Inks

Introduction

Mystery novels and old spy movies often feature secret messages written in invisible inks that can be read only when treated with certain chemicals. Although invisible inks are no longer a fad, they are fun to make and involve some interesting chemistry. In this activity you'll learn several ways to write secret messages with invisible inks and the chemistry that makes them visible.



Materials

cobalt (II) chloride [CoCl₂] solution
iron (III) chloride [FeCl₃] solution
lemon juice

masking tape
paper
potassium thiocyanate [KSCN] solution

Equipment

cardboard
hair dryer (*optional*)
hot plate or light bulb

small paint brushes or cotton swabs
spray bottles

Safety Considerations

- Cobalt chloride is toxic; YOU MUST WEAR GOGGLES AND GLOVES AT ALL TIMES DURING THIS LAB.
- Sometimes chemicals from previous labs still remain in glassware and on other lab equipment; wash all lab equipment before and after performing this lab.
- Wash your hands thoroughly after completing this lab.

Procedure #1 – lemon juice and heat

1. Using a small, clean brush or a cotton swab, write a secret message on a piece of paper with lemon juice.
2. Allow the paper to air dry or use a hair dryer on the cold air setting to dry it.
3. After paper has completely dried, heat the paper gently by holding it at each end and slowly passing it back and forth above a hot plate or warm light bulb.
4. Record your observations in the Data Table under “Procedure #1”.

Procedure #2 – cobalt chloride and heat

1. Using cobalt chloride solution instead of lemon juice, repeat Procedure #1. Cobalt chloride is toxic, so you must wear goggles and gloves for this step.
2. Record your observations in the Data Table under “Procedure #2”.

Procedure #3 – potassium thiocyanate and iron (III) chloride

1. Using a small, clean brush or a cotton swab, write a secret message on a piece of paper with potassium thiocyanate solution. Potassium thiocyanate is toxic, so you must wear goggles and gloves for this step.
2. Allow the paper to air dry or use a hair dryer on the cold air setting to dry it.
3. After paper has completely dried, tape it to a large piece of cardboard and spray it with iron (III) chloride solution.
4. Record your observations in the Data Table under “Procedure #3”.

Clean-up

1. Dispose of all used paper and rubber gloves in the trash.
2. Return all equipment to its proper location.
3. Wipe down your lab area.
4. Wash your hands before leaving the lab.

Data Table

Paper Observations	
Procedure #1	
Procedure #2	
Procedure #3	

Questions

1. Based on your observations, which invisible ink was the easiest to see after being revealed? Why?

2. Based on your observations, which invisible ink was the most difficult to see after being revealed? Why?

3. In Procedure #1, when citric acid from the lemon juice is heated, it chars the paper by removing water from the cellulose to produce black carbon. Do you think this is a temporary or permanent change? Why?

4. In Procedure #3, the iron (III) ion (Fe^{3+}) reacts with the thiocyanate ion (SCN^-) to produce the dark-red complex, iron (III) thiocyanate ($\text{Fe}(\text{SCN})_3$). Why is it more effective to use the KSCN on the paper first instead of the FeCl_3 ?

5. List one way you could change this lab and describe how your results might be different.
